Short Communication

A modified freeze-corer for sampling invertebrates in streams

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Abstract

A modification of the freeze core sampler of Marchant & Lillywhite (1989), which makes it easier to use in moderately remote field localities is described. The principal changes are the use of pelletised carbon dioxide (CO^2) as the freezing agent rather than liquid CO^2, a reduction in the length of the standpipe and, importantly, the addition of a black rubber insulating jacket round the standpipe to reduce potential heating problems and core breakage at the sediment-water interface. The apparatus can be operated by two people and is particularly suitable for use in moderately small streams with compact beds.

Keywords: Freeze corer - stream ecology – benthic invertebrates - dry ice - hyporheos

Introduction

The hyporheic zone, i.e. the saturated interstitial spaces within the stream bed, is known to provide an important habitat for stream invertebrates (Ward 1992, Palmer 1993, Allan 1995) with some species occurring to depths of at least 70 cm (Coleman & Hynes 1970, Williams & Hynes 1974, Marchant 1988, 1995). However, most conventional samplers (e.g., Surber samplers) allow penetration of the stream bed to depths of only 5-10 cm and can lead to substantially inaccurate estimates of benthic invertebrate abundance (Adkins & Winterbourn 1999).

The need for quantitative sampling of the hyporheos has led to the investigation of alternative sampling methods, which have included colonisation pots, pumping of sediments, and various kinds of corers (Fraser & Williams 1997). Freeze corers that operate by freezing bed sediments to a metal pipe hammered into the stream bed provide one of the better quantitative methods (Fraser & Williams 1997) and overcome some of the disruptive problems associated with mechanical corers (Williams & Hynes 1974).

Typically, "cores" are frozen to the outside of a pipe (Pugsley & Hynes 1983, Marchant & Lillywhite 1989, Bretschko, 1985), which means that the volume of substrate frozen cannot be controlled. Nevertheless, the first freeze-corers were designed to collect small samples within narrow tubes (Shapiro 1958, Efford 1960), and recently Hill (1999) described a 20 cm diameter,

double-walled freeze corer for the collection of invertebrates and sediments within the top 10-15 cm of the stream bed. In all these devices, freezant is poured into the space between the walls of the sampler to freeze the material inside, so producing an even shaped core. Although Hill's sampler was designed for use in shallow streams (including stony ones), its large diameter and mode of operation (the corer must be pushed into the substrate by hand), would probably prevent it from being used to obtain deep cores (30 cm or more) in most stony streams.

In this paper, we describe a freeze-corer based on the model used by Marchant & Lillywhite (1989), but modified in several ways to facilitate its use in localities accessible only on foot. In particular, solid dry ice is used as the freezing agent rather than liquid carbon dioxide or liquid nitrogen. Liquid coolants are rarely a practical option for use at remote sites due to the volumes required, and the need to store and carry them in cylinders over rough terrain. Solid carbon dioxide (dry ice) can be transported in lightweight polystyrene boxes ('chillybins') and is relatively safe and easy to transport and handle in the field. Other differences from the corer of Marchant & Lillywhite are the use of a shorter standpipe, and therefore, reduced weight, and the incorporation of a thick, rubber insulation jacket around the standpipe at the substrate surface to reduce potential heating problems. Marchant & Lillywhite placed a heavy, open-ended, galvanised iron cylinder around the standpipe for this purpose, but it added further to the weight of the apparatus. In total, our modifications result in lighter equipment that can be carried, assembled and operated by two people.

Design, construction and operation

The unperforated standpipe is made from 35 mm internal diameter galvanised pipe, with a conical steel driving tip welded to the lower end (Fig. 1A), and two steel rings welded to its outer surface. The upper ring supports a steel, driving cap (Fig. 1B), which protects the top of the pipe when it is being driven into the substrate. The lower ring supports a separate lifting assembly (Fig.1 C) that is held in position by a metal pin inserted through holes bored in the lifting assembly and the standpipe. At 1.4 m in length the pipe is 43 cm shorter than that used by Marchant & Lillywhite, a reduction that does not affect the depth to which the sampler can be driven.

In the field, the standpipe is hammered vertically into the streambed with a sledge hammer (to a depth of 30 cm in the study of Adkins & Winterbourn 1999). The depth of penetration is measured with a graduated rod from a predetermined point on the driving cap. Rubber bungs are inserted into the top of the standpipe and the small side holes so as to prevent the entry of moisture that could interfere with the freezing process. The pipe is left for 24 hours before freezing to allow fauna to recover from any disturbance associated with the hammering (Marchant & Lillywhite 1989). Thick (10 mm) rubber tubing (insulation) is placed around the outside of the standpipe to reduce the likelihood of heating by water flowing past during the freezing operation.

The freezing procedure involves pouring dry ice pellets into the standpipe through a plastic funnel. A wooden rod is used to gently tamp these down. Timing of the operation begins once the pellets have been packed into the standpipe to just below the level of the lifting assembly anchor holes. Satisfactory cores are usually frozen to the outside of the pipe within 20 minutes, but the time needed is influenced by air and water temperature. Freezing is achieved more rapidly in winter. In summer, the addition of a small quantity of alcohol to the dry ice in the pipe aids the freezing process.

Our apparatus and operational technique differ from those of Marchant & Lillywhite (1989) in a number of ways. The pelleted dry ice used as the refrigerant is more convenient to

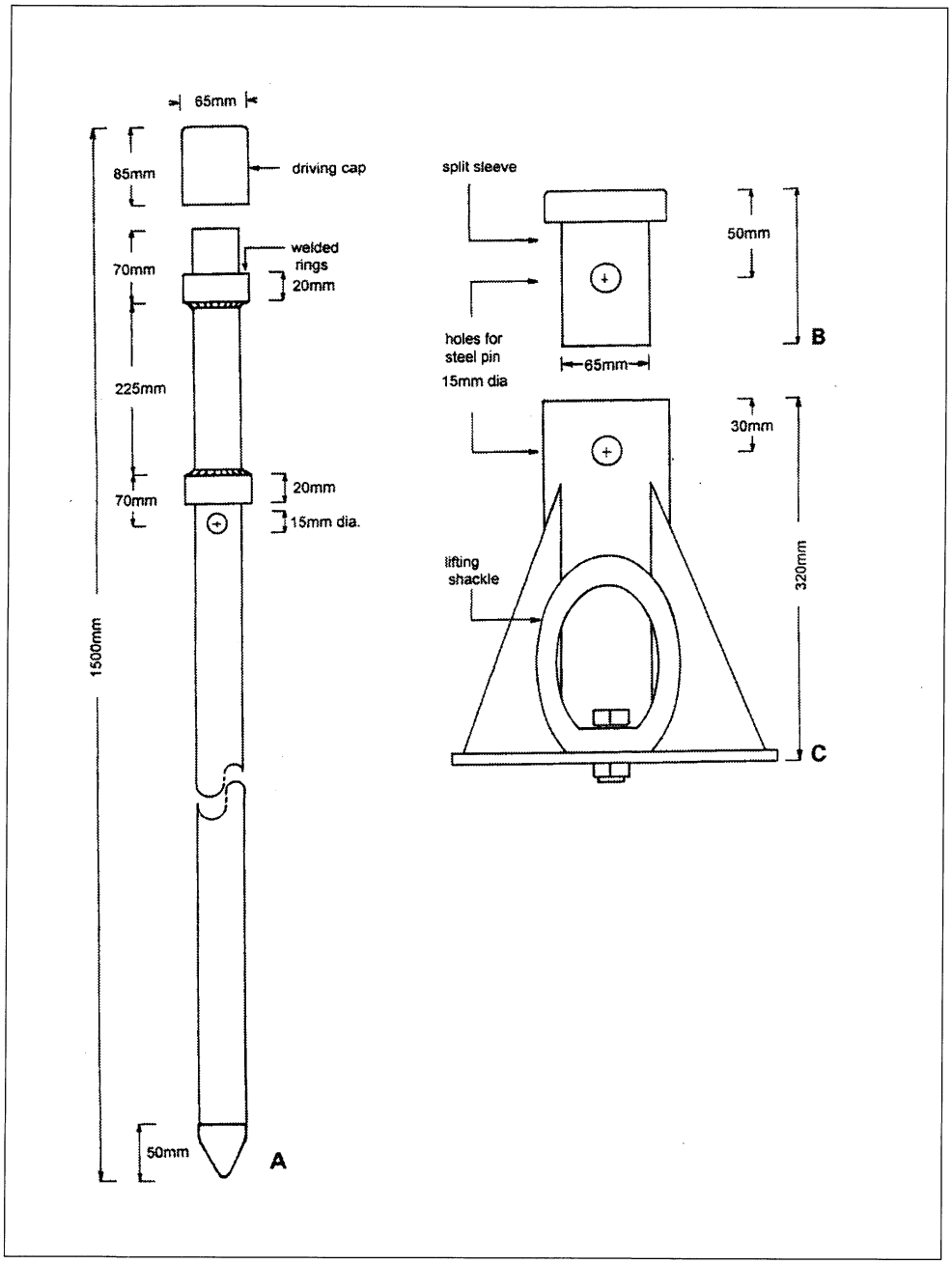

Figure 1. Freeze corer
A. Standpipe and driving cap, B. Split sleeve, C. Lifting assembly

handle in the field, being lighter to transport than cylinders of liquid CO^2. The shorter pipe also means less weight to carry. Because the dry ice remains in the pipe, there is not the same urgency in lifting it from the substrate. However, using dry ice means a longer freezing time is required; about 20 minutes compared with 4-6 minutes with liquid carbon dioxide.

To remove a standpipe and core, the lifting assembly is fitted over the pipe, two halves of a steel, split-sleeve are fitted under the lower ring (Fig.1C) and a steel pin is inserted to secure the apparatus. Two truck jacks are then fitted into the loops on the assembly and the whole apparatus is jacked vertically out of the stream bed. The frozen sediment is removed from the outside of the pipe in whatever lengths are required using a bolster and hammer. The sediment and associated fauna are then placed in bags and kept frozen until processing can be carried out.

Because frozen "cores" have uneven shapes and volumes (Fig. 2), samples need to be standardised to an equivalent volume of sediment so that comparisons can be made. In our study of depth distributions of invertebrates (Adkins & Winterbourn 1999) the volumes of sediment in 10 cm long sections of cores were determined by displacement of water, and invertebrate abundance was converted to equivalent numbers per 9L of substrate. Nine litres was chosen since it approximates the volume of substrate disturbed when using a standard Surber sampler (30 x 30 x 10 cm).

In summary, we consider that the modifications we have made to the Marchant & Lillywhite freeze core sampler make it a little more "user friendly" without reducing its effectiveness. The rubber sleeve placed around the standpipe immediately above the substrate-water interface helps prevent breakage in the upper 10 cm of cores, a potential problem with freeze-coring noted by Marchant & Lillywhite (1989) who enclosed their corer in a heavy, iron

Figure 2. Frozen core on standpipe

cylinder for this purpose. The sampler can be operated comfortably by two persons in moderately remote conditions, and is particularly recommended for use in moderately small streams with fairly compact bed sediments.

Acknowlegdements

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References

Adkins, S. C. & Winterbourn, M. J. (1999). Vertical distribution and abundance of invertebrates in two New Zealand stream beds: a freeze coring study. *Hydrobiologia 400*: 55-62.

Allan, J.D. (1995). Stream Ecology. Structure and Function of Running waters. Chapman & Hall, London.

Bretschko, G. (1985). Quantitative sampling of the fauna of gravel streams (Project RITRODAT-LUNZ). *Verhandlungen der Internationalen Vereinigung für Theoretische und Angewandte Limnologie 22*: 2049-2052.

Coleman, M. J. & Hynes, H. B. (1970). The vertical distribution of the invertebrate fauna in the bed of a stream. *Limnology and Oceanography 15*: 31 -40.

Efford, I. E. (1960). A method of studying the vertical distribution of the bottom fauna in shallow waters. *Hydrobiologia 16*: 288 -292.

Fraser, B. G. & Williams, D. D. (1997). Accuracy and precision in sampling hyporheic fauna. *Canadian Journal of Fisheries and Aquatic Sciences 54*: 1135-1141.

Hill, M.T.R. (1999). A freeze-corer for simultaneous sampling of benthic macroinvertebrates and bed sediment from shallow streams. *Hydrobiologia 412*: 213-215.

Marchant, R. (1988). Vertical distribution of benthic invertebrates in the bed of the Thompson River, Victoria. *Australian Journal of Marine and Freshwater Research 39*: 775 - 784.

Marchant, R. (1995). Seasonal variation in the vertical distribution of hyporheic invertebrates in an Australian upland river. *Archiv für Hydrobiologie 134*: 441-457.

Marchant, R. & Lillywhite, P. (1989). A freeze-corer for sampling stony river beds. *Bulletin of the Australian Society for Limnology 12*: 41-48.

Palmer, M.A. (1993). Experimentation in the hyporheic zone: challenges and prospects. *Journal of the North American Benthological Society 12*: 84-93.

Pugsley, C.W. & Hynes, H.B.N. (1983). A modified freeze-core technique to quantify the depth distribution of fauna in stony stream beds. *Canadian Journal of Fisheries and Aquatic Sciences 40*: 637-643.

Shapiro, J. (1958). The core-freezer- a new sampler for lake sediments. *Ecology 39*: 758.

Ward, J.V. (1992). Aquatic Insect Ecology, Vol.1. Biology and Habitat. Wiley, New York.

Williams, D.D. & Hynes, H.B.N. (1974). The occurrence of benthos deep in the substratum of a stream. *Freshwater Biology 4*: 233-256.